National Aeronautics and Space Administration

NASA Advisory Council
Human Exploration and Operations Committee

Research Subcommittee Report
One Year Study and Genome Project

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Human Exploration & Operations Mission Directorate

Biological and Physical Sciences

- **NASA's Space Life and Physical Sciences Research and Applications Division (SLPS) has been formulated to execute high quality, high value research and application activities in the areas of:**
  - Space Biology
  - Physical Sciences
  - Human Research
- **These programs conduct fundamental and applied research to advance basic knowledge and to support human exploration in the environment of space.**
- **Division serves as the Agency liaison with the ISS National Laboratory management organization, the Center for the Advancement of Science in Space (CASIS).**

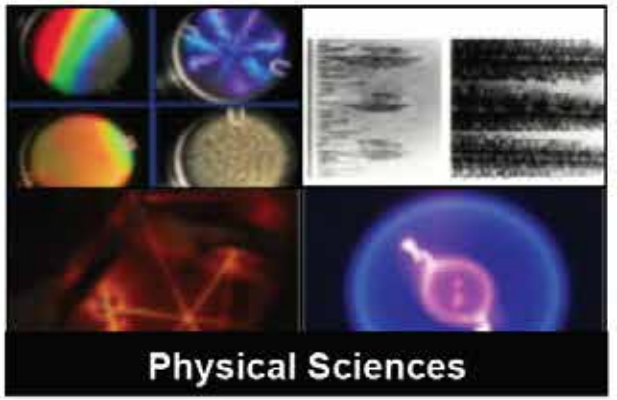
SLPS Research and Application Focus Areas

Space Biology

- Uses the space environment to enhance understanding of the response of living organisms and biological processes to spaceflight conditions.
- Works toward an understanding of the requirements of terrestrial life in non-Earth environments. Provides access to model biomedical research systems.

Human Research

- Develops scientific and technological foundations for a safe, productive human presence in space for extended periods.
- Focuses on investigating and mitigating the highest risks to human health and performance in order to enable safe, reliable, and productive human space exploration.

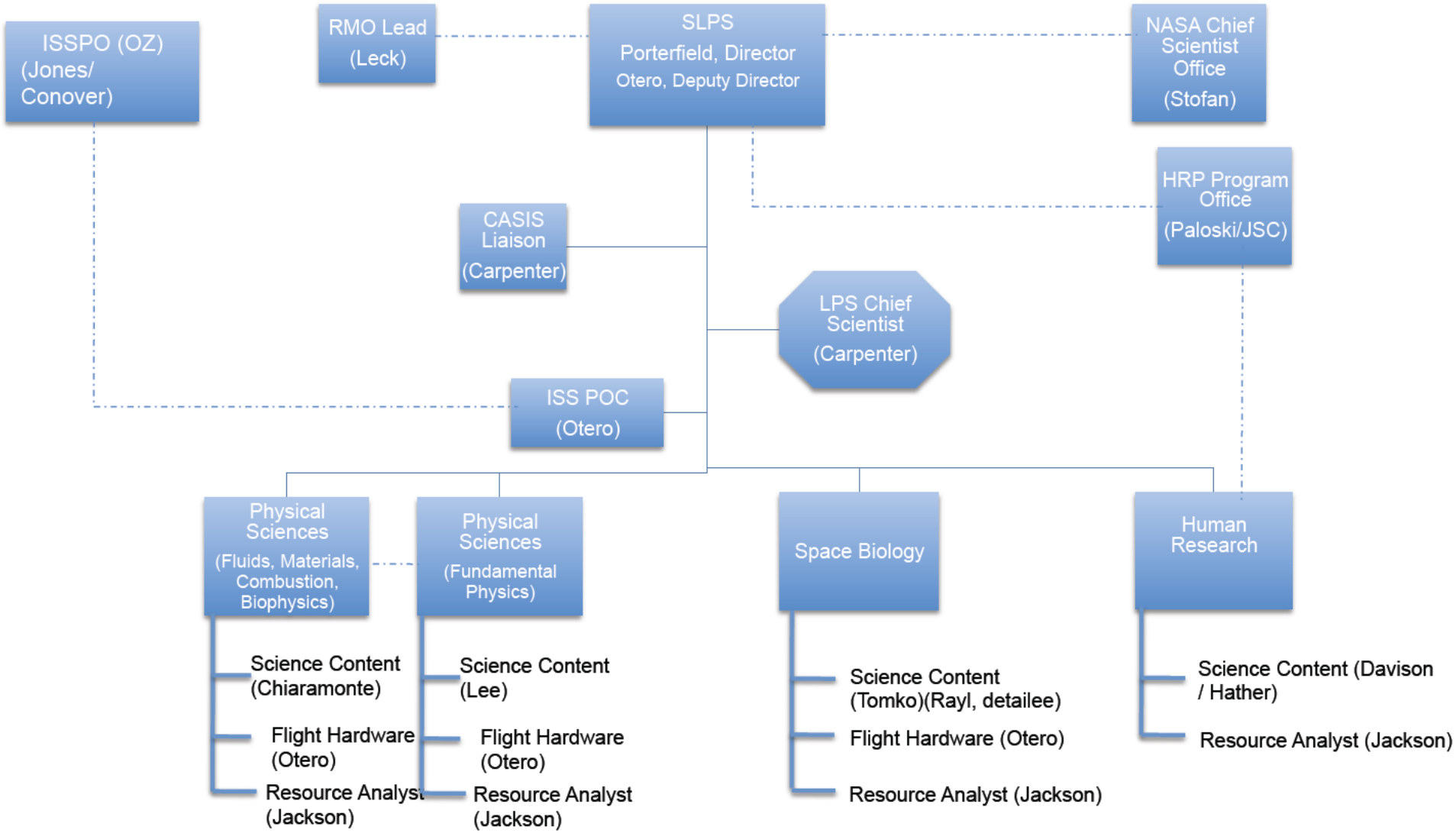


Physical Sciences

- Conducts fundamental and applied research in space to explore the processes that form materials and determine the performance of fluid, thermal, and combustion systems.
- Builds engineering knowledge to enable the design of fluid, thermal, and chemical process devices for future space exploration systems.

- Applies this knowledge and technology to improve our Nation's competitiveness, education and the quality of life on Earth. Creates the new discoveries for CASIS activities.

SLPSRA Organization Chart



NASA Human Research Program (HRP)

Mission

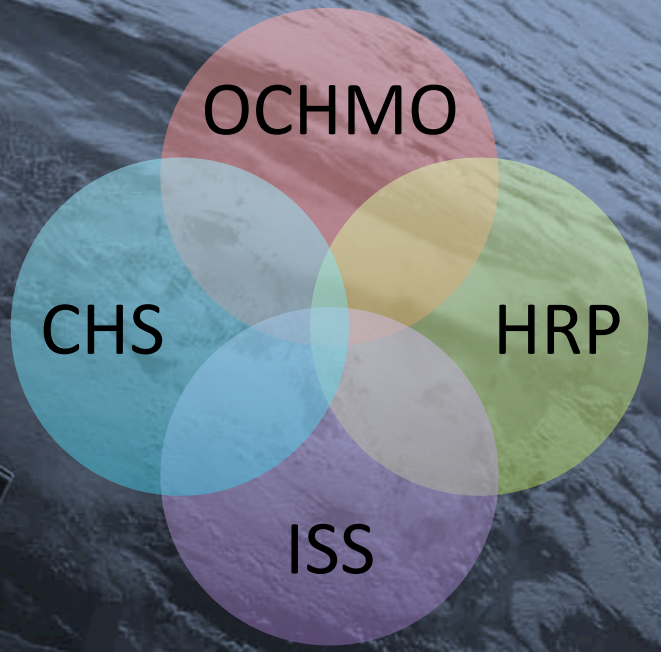
- To enable space exploration beyond low Earth orbit by reducing the risks to human health & performance through a focused program of basic, applied, and operational research

Goals

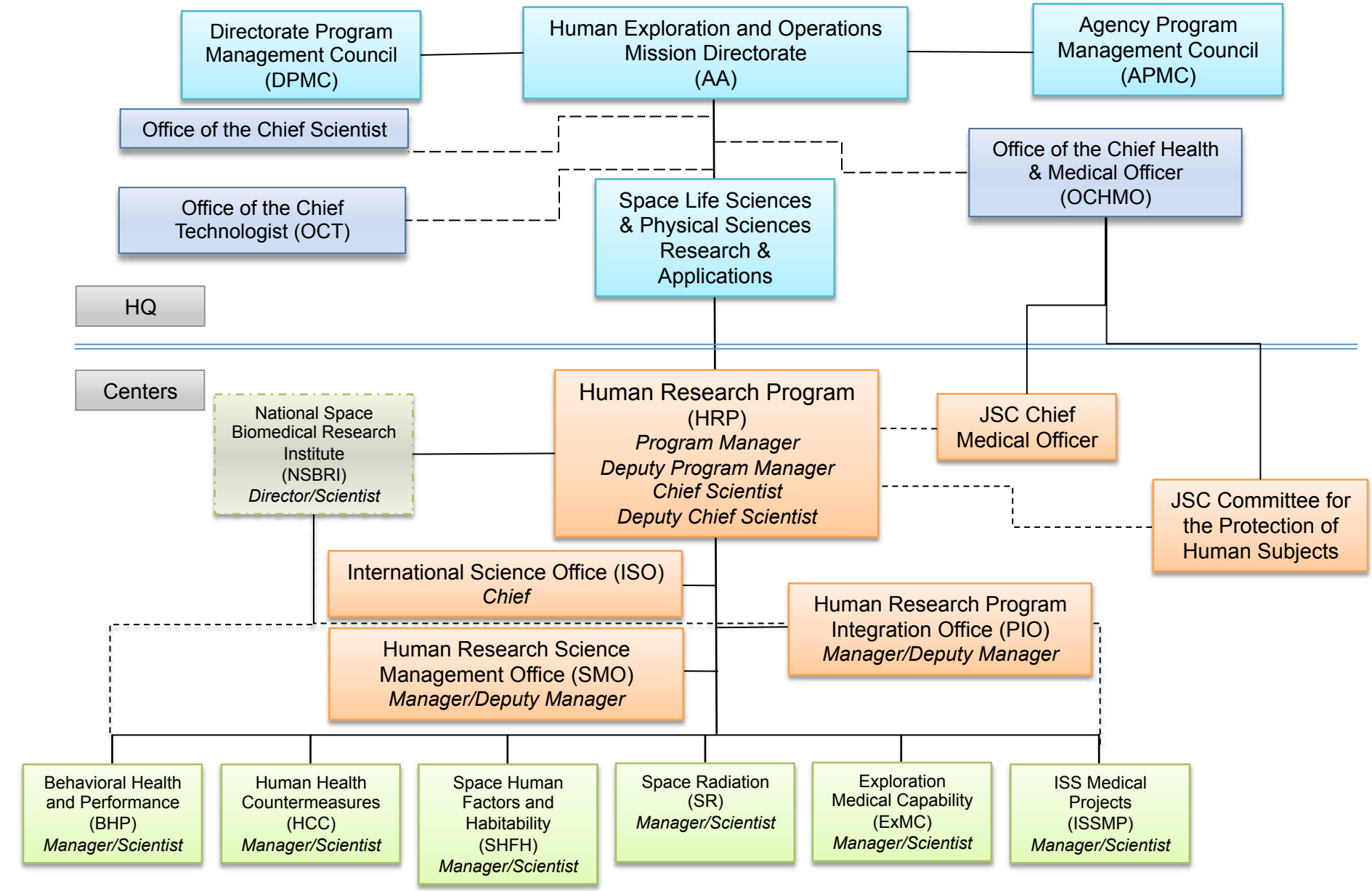
- Perform research necessary to understand and reduce spaceflight human health and performance risks in support of exploration
- Develop and validate technologies that serve to characterize and reduce medical risks associated with human spaceflight
- Enable development of human spaceflight medical and performance standards

Integrated Human Health Risk Mitigation

- Policy, Operations, and Research are integrated through a Human Health Risk Framework
  - Office of the Chief Health and Medical Officer (OCHMO)
    - Medical Policy, Health and Performance Standards, and Bioethics (IRB, ACUC, Risk Threshold)
  - Crew Health and Safety (CHS)
    - Medical Operations and Occupational Health (career health care/post career monitoring)
  - NASA Human Research Program (HRP)
    - Human health & performance research in support of space exploration
      - Perform research necessary to understand & reduce health & performance risks
  - International Space Station (ISS)
    - Medical Operations on ISS
      - Medical Tests and hardware



Overview: Organization



Hazards Create Risks During Space Flight

Space Flight Hazards to Crew Members:

decreased gravity/gravity transitions*

bone, muscle, cardiovascular, sensory-motor, nutrition, immunology, human factors, clinical medicine

isolation/confinement*

behavior/performance, nutrition, immunology, toxicology, microbiology

altered light-dark cycles*

behavior/performance

increased radiation*

carcinogenesis, tissue degeneration(cardiovascular), CNS effects, acute (SPEs)

distance from Earth

behavior/performance, autonomy, food systems, clinical medicine

**effect severity increases with mission duration*

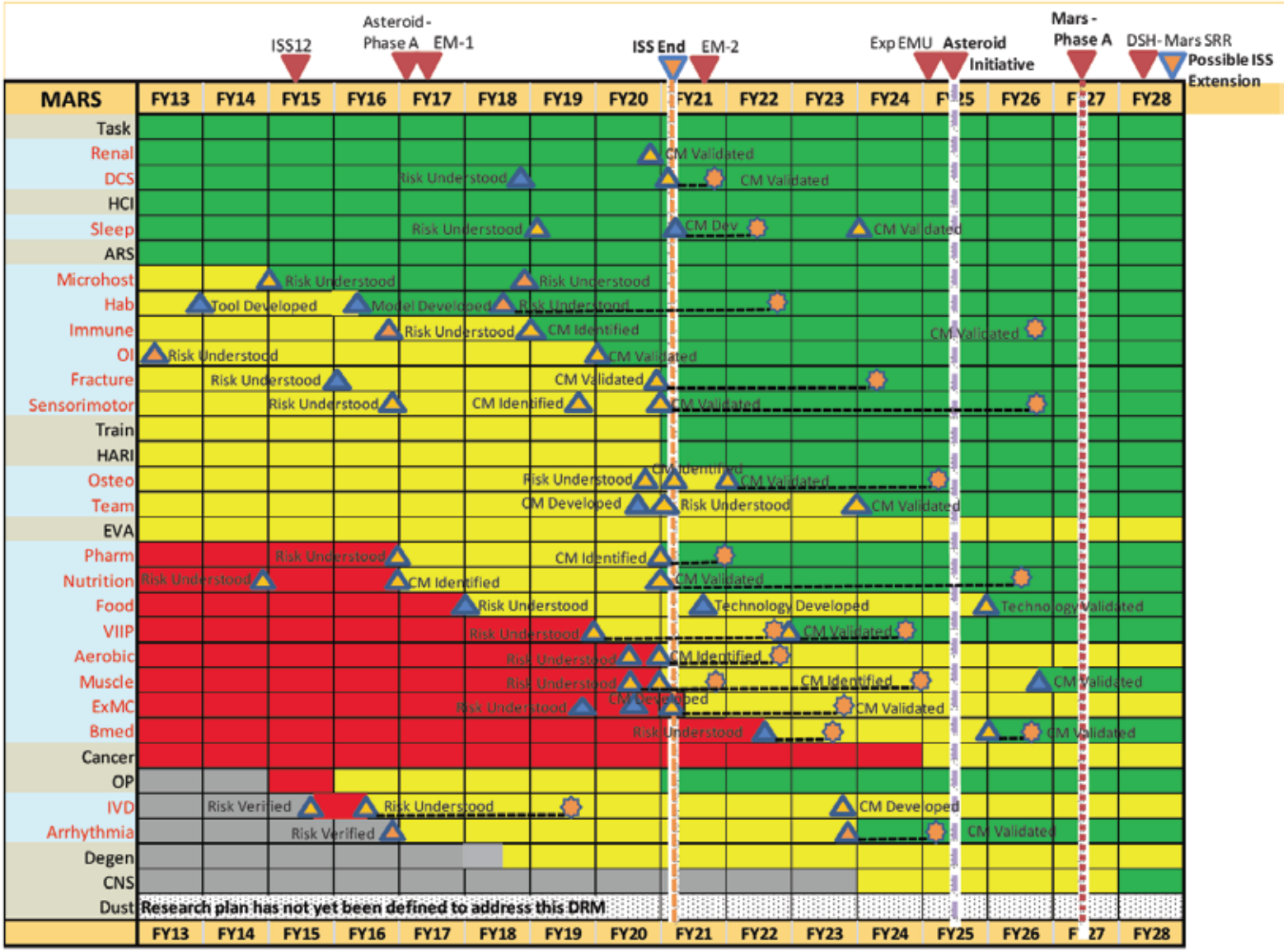
International Coordination: Exploration Biomedical Challenges

Not mission limiting	Not mission limiting, but increased risk	Potentially Mission limiting

Human Health and Performance Risks Coordinated with all International Partners		Mission			
		ISS 6 mo	Lunar 6 mo	NEA (1yr)	Mars (3yr)
Musculoskeletal	Long-term health risk of Early Onset Osteoporosis; Mission risk of reduced muscle strength and aerobic capacity				
Sensorimotor	Mission risk of sensory changes/dysfunctions				
Ocular Impairment	Mission and long-term health risk of Microgravity-Induced Visual Impairment and/or elevated Intracranial Pressure (VIIP)			U	U
Nutrition	Mission risk of behavioral and nutritional health due to inability to provide appropriate quantity, quality and variety of food				
Autonomous Medical Care	Mission health risk due to inability to provide adequate medical care throughout the mission (Includes onboard training, diagnosis, treatment, and presence/absence of onboard physician)				
Behavioral Health and Performance	Mission and long-term behavioral health risk.				
Space Radiation	Long-term risk of carcinogenesis and degenerative tissue disease due to radiation exposure				
Toxicity	Mission risk of exposure to a toxic environment without adequate monitoring, warning systems or understanding of potential toxicity (dust, chemicals, infectious agents)				
Autonomous Emergency Response	Medical risks due to life support system failure and other emergencies (fire, depressurization, toxic atmosphere, etc.), crew rescue scenarios				
Hypogravity	Long-term risk associated with adaptation during IVA and EVA on the Moon, asteroids, Mars (vestibular and performance dysfunctions) and post-flight rehabilitation				U

Integrated Human Health Risk Reduction Schedule

- *HRP initial assessment*



Legend

HRP Risk
Requires ISS

HRP Risk
ISS Not Required

Milestone uses ISS

Milestone slip due to insufficient "N" on ISS

Risk Rating

- Unacceptable
- Acceptable
- Controlled
- Insufficient Data

Response to the Decadal Survey: Perspectives and Approaches for Going Forward

- Chartered by Congress the National Academy of Science Commissioned a National Research Council decadal survey of NASA Life and Physical Sciences

- The Resulting report serves the SLPS Division in HEO as a guideline for developing applied and fundamental research that serves to promote the NASA human exploration mission

- Decadal recommendations serve the ultimate direction in prioritization of ISS research efforts coming from the SLPS Division at HQ

- NASA/SLPS is directly responsible back to the NAS/NRC and congress in how the recommendations are addressed.

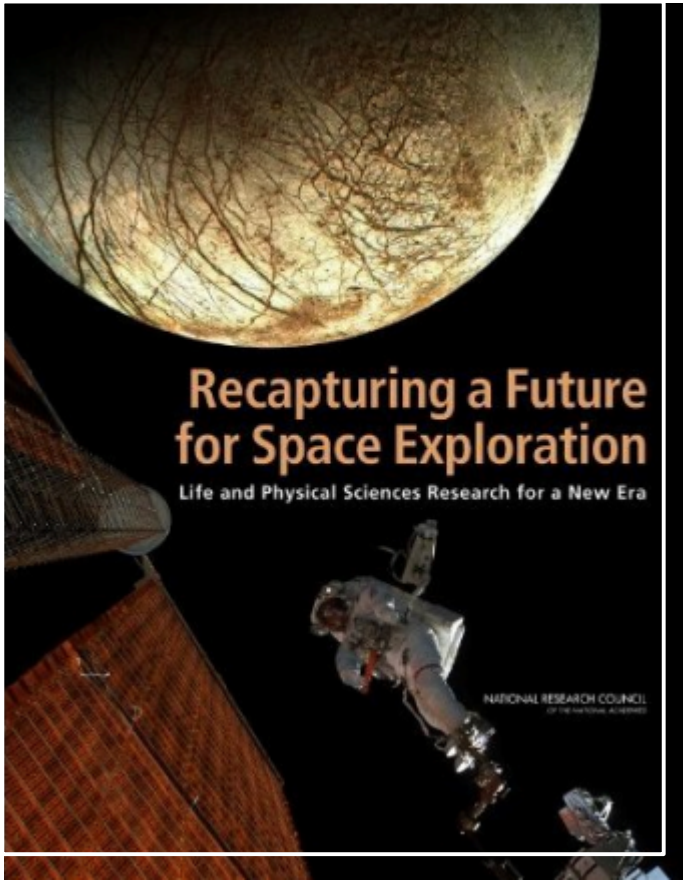


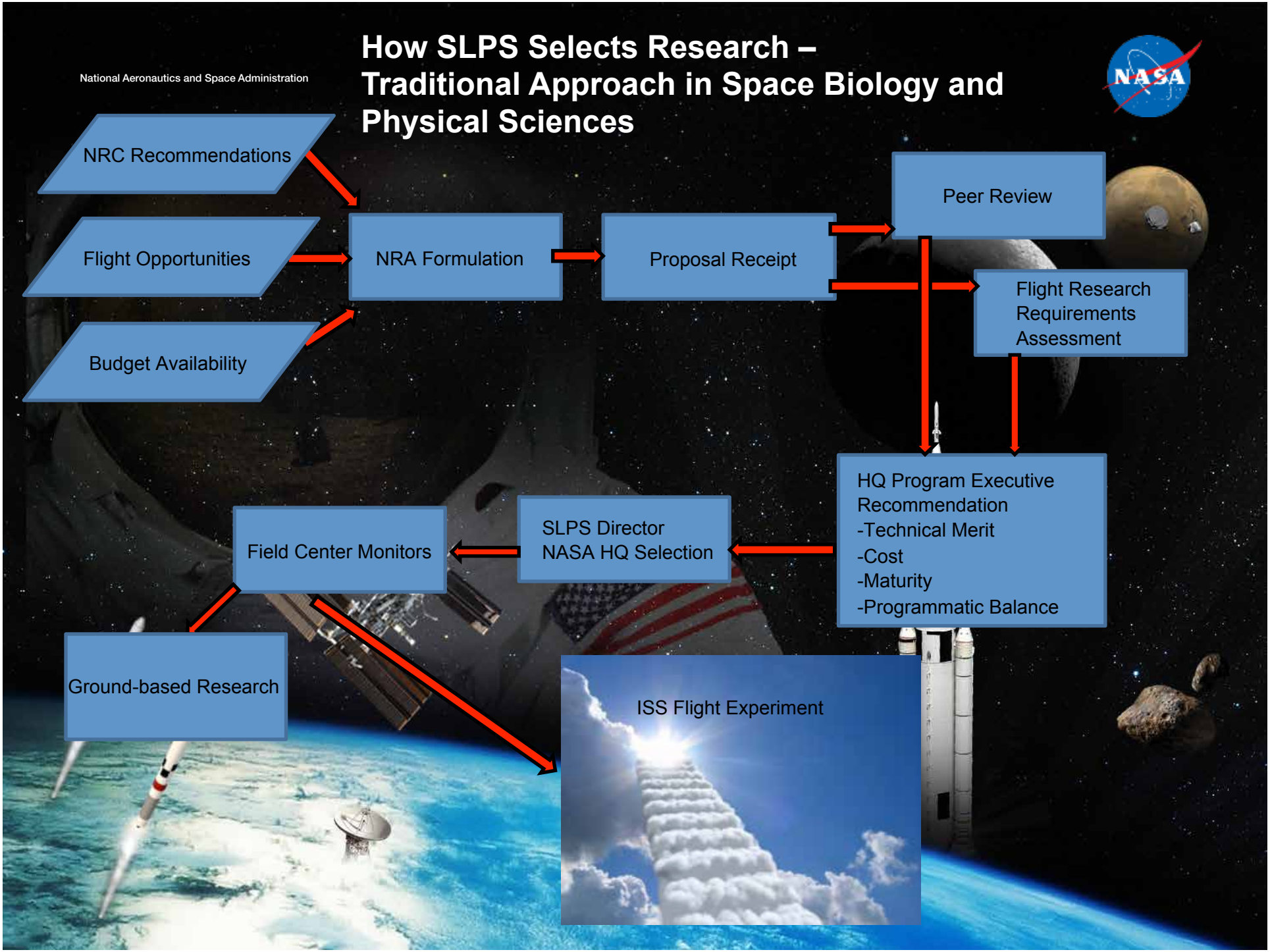
TABLE 13.2 Highest-Priority Recommendations That Provide **High** Support in Meeting Each of Eight Specific Prioritization Criteria

	<----------Prioritization Criteria---------->							
	(1) Positive Impact on Exploration Efforts, Improved Access to Data or to Samples, Risk Reduction	**(2)** Potential to Enhance Mission Options or to Reduce Mission Costs	**(3)** Positive Impact on Exploration Efforts, Improved Access to Data or to Samples	**(4)** Relative Impact Within Research Field	**(5)** Needs Unique to NASA Exploration Programs	**(6)** Research Programs That Could Be Dual-Use	**(7)** Research Value of Using Reduced-Gravity Environment	**(8)** Ability to Translate Results to Terrestrial Needs
Life Sciences	P2, P3, B1, B2, B3, B4, AH1, AH2, AH3, AH5, AH6, AH7, AH8, AH9, AH10, AH11	P3, B1, B2, B3, B4, AH6, AH9, AH10, AH11	P3, B4, AH1, AH2, AH3, AH5, AH6, AH7, AH8, AH9, AH10, AH11	P1, P2, B3, B4, AH9, AH10, AH11, AH16	P1, P2, P3, AH1, AH2, AH3, AH4, AH5, AH6, AH7, AH8, AH9, AH10, AH11, AH16	B1, B2, B3, B4, AH1, AH2, AH3, AH4, AH5, AH6, AH7, AH9, AH10	P1, B1, B4, AH12, AH16	B1, B2, B3, B4, AH1, AH2, AH3, AH4 AH5, AH6, AH7
Translational Life Sciences	CCH2, CCH4, CCH7	CCH2, CCH4, CCH6, CCH7	CCH2, CCH4, CCH6, CCH7, CCH8	CCH2, CCH6	CCH1, CCH2, CHH3, CCH6, CCH7, CCH8		CCH1, CHH2, CHH3, CCH7, CCH11	
Physical Sciences	AP1, AP4, AP6, AP8, AP11	AP1, AP2, AP10, AP11	AP1, AP2, AP3, AP10, AP11	FP1, FP2, FP3, AP5, AP7, AP8, AP9	AP1, AP2, AP3, AP4, AP6, AP11	AP7, AP8, AP9, AP10	FP1, FP2, FP3, FP4, AP1, AP2, AP5, AP6, AP7, AP9	AP1, AP2, AP7, AP8, AP9
Translational Physical Sciences	TSES1, TSES2, TSES3, TSES14	TSES1, TSES3, TSES5, TSES10	TSES14		TSES2, TSES3, TSES4, TSES5, TSES6, TSES7, TSES12, TSES13, TSES14, TSES 16	TSES10, TSES11, TSES12	TSES1, TSES2, TSES3, TSES4, TSES5, TSES12, TSES13, TSES14, TSES15, TSES16	TSES10

NOTE: Identifiers are as listed in Table 13.1 and correspond with the recommendations listed there and also presented with clarifying discussion in Chapters 4 through 10.

National Aeronautics and Space Administration

How SLPS Selects Research – Traditional Approach in Space Biology and Physical Sciences



Research Subcommittee of the HEO Committee

NASA Advisory Council Recommendation in March, 2012 to create a subcommittee that "…advises NASA on the research and educational needs that are required to support a plan for the long-range human exploration of space. The subcommittee should include a breadth of perspectives that encompass research and higher educational needs, not representation of specific disciplines."

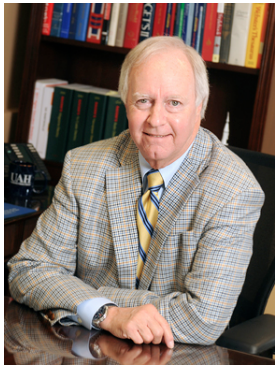
From the Research Subcommittee Terms of Reference-

The Research Subcommittee will support the HEO Committee in its missions by meeting the following objectives:

1. **Provide advice and recommendations on the overall objectives, approach, content, and structure of research activities in HEOMD.**
2. **Provide assessments on the effectiveness of relationships between HEOMD's missions and stakeholders in the research and educational sectors.**

HEOC Research Subcommittee

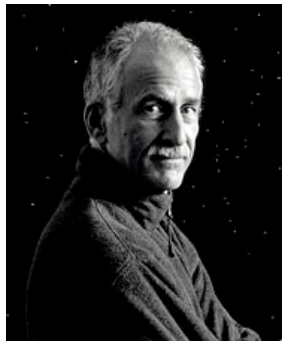
Dr. David Longnecker, M.D., is the chair of the subcommittee. He is a member of the Human Exploration and Operations Committee. He is a Director of the Association of American Medical Colleges, and is the Robert D. Dripps Professor Emeritus of Anesthesiology and Critical Care at the University of Pennsylvania. He has served as President of the American Board of Anesthesiology, and is a member of the Institute of Medicine. At the IOM, he has served as chair of the Standing Committee on Aerospace Medicine and the Medicine of Extreme Environments



Dr. Robert A. Altenkirch currently serves as president of The University of Alabama in Huntsville. Prior to this appointment, he served as president of New Jersey Institute of Technology. Dr. Altenkirch earned his B.S. from Purdue University, an M.S. from the University of California, Berkeley, and his Ph.D. from Purdue. Other previous positions include vice president for research at Mississippi State University and dean of the College of Engineering and Architecture at Washington State University

HEOC Research Subcommittee

Dr. M. Katherine Banks is the Dean of Engineering at Texas A&M University. Previously she had been head of the School of Civil Engineering at Purdue University. At Purdue, she also served as director of the EPA Hazardous Substance Research Center. She is a Fellow of the American Society of Civil Engineers and served as editor-in-chief for the *ASCE Journal of Environmental Engineering* and associate editor of the *International Journal of Phytoremediation*.



Dr. Jeffrey A. Hoffman is a Professor of the Practice in the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology. At MIT he also directs the Massachusetts Space Grant Consortium. He served as the NASA Europe Representative, and flew on five Shuttle missions as a NASA astronaut. Before joining the astronaut corps, he worked as an astrophysicist, with a focus on gamma ray and x-ray astronomy.

HEOC Research Subcommittee

Dr. Terri L. Lomax serves as the Vice Chancellor for Research, Innovation and Economic Development at North Carolina State University. Previous positions include Deputy Associate Administrator for Research in the Exploration Systems Mission Directorate, and Director of the NASA Fundamental Space Biology Division. She was a member of the faculty at Oregon State University from 1987 until 2006, with research interests in plant physiology and genetics.

Dr. Stein Sture is Vice Chancellor for Research at the University of Colorado, Boulder. He also is the Huber and Helen Croft Endowed Professor in the Department of Civil, Environmental, and Architectural Engineering in the College of Engineering and Applied Science. He has been a faculty member at CU Boulder since 1980. His fields of expertise are in the areas of experimental and analytical modeling in solid mechanics, geomechanics, computational geotechnics, and geotechnical engineering.

HEOC Research Subcommittee

Dr. Kathryn C. Thornton is a Professor at the University of Virginia in the School of Engineering and Applied Science in the Department of Mechanical and Aerospace Engineering. She served from 1999 until 2012 as the Assistant Dean and later Associate Dean for Graduate Programs. Selected as an astronaut candidate by NASA in May 1984, Thornton is a veteran of four space flights. Since leaving NASA, Thornton has served on several review committees and task groups, including the National Research Council Study: Science Opportunities Enabled by Constellation (2007) as co-chair.

Research Subcommittee Activities

First meeting 17 April, 2013 – videocon

Organizational focus- Introductions, overview, goals and priorities

31 July 2013 – Washington DC

Relationship between research and technology- SLPS, HRP, and Advanced Exploration Systems.

24 February 2014 – Washington DC

Role of SLPS in HEO goals, SLPS research planning, ISS resource planning. Open source science

HEOC Research Subcommittee

RS meeting on February 24, 2014 included discussions with Bill Gerstenmaier on the role of research in HEOMD and with Marshall Porterfield on research planning in SLPS. The implementation of “open source science” was a focus of this discussion

Proposed finding -

Short Title of Finding: NASA Approach to Open Source Space Research

Finding: The Human Exploration and Operations Advisory Committee endorses NASA’s development of an Open Source approach for the Space Life and Physical Sciences GeneLab initiative and it encourages continued development in that direction. The Committee also supports the proposed development of linkages with other public, private and governmental organizations that can foster both operational success and public engagement with this initiative. The Research Subcommittee of the HEO Advisory Committee will request regular updates to this initiative at each of its next several meetings.

One Year Increment

ISS Crew: Scott Kelly, Mikhail Kornienko Sign On For One-Year Mission

Posted: 11/26/2012 9:29 am EST Updated: 11/26/2012 9:40 am EST

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FOLLOW: Video, Scott Kelly, International Space Station, Iss Crew, Iss Mission, Mikhail Kornienko, International Space Station, Science News

By: Tariq Malik
Published: 11/26/2012 08:12 AM EST on SPACE.com

A veteran NASA space commander and Russian cosmonaut have signed on for the ultimate space voyage: a yearlong trip on the International Space Station.

American astronaut Scott Kelly and Russian cosmonaut Mikhail Kornienko will launch on the one-year space station flight in spring 2015 and return to Earth in spring 2016, NASA officials announced today (Nov. 26). They will begin their mission training in early 2013.

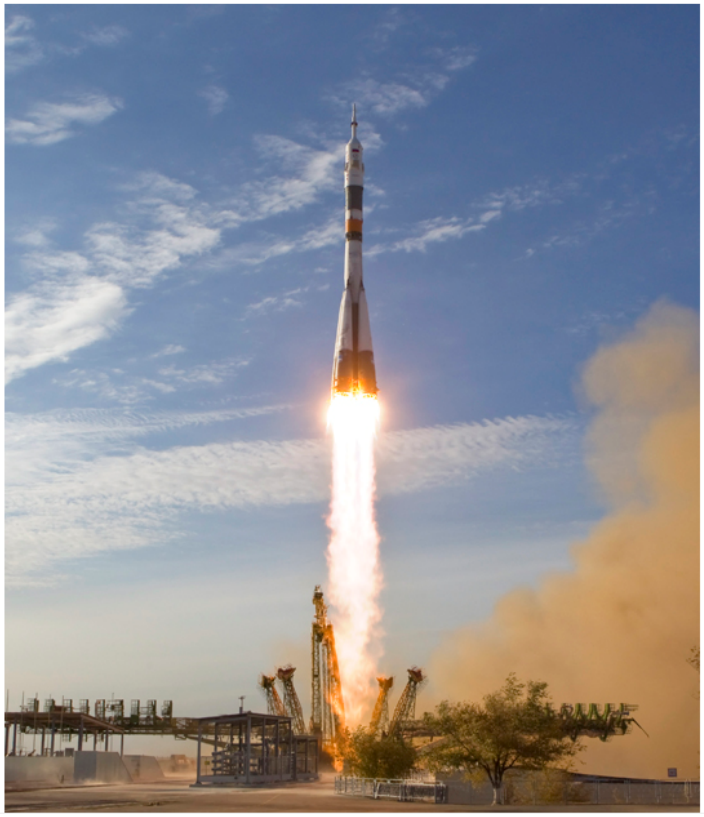
HOME > SCIENCE

Astronaut Scott Kelly Preparing for Unprecedented One Year in Space; Mission to Experiment on His Bone Mass, Vision, Immune System

By Latin Times Staff Writer, Dec 07, 2012 08:00 PM EST

0 Comments Like 0 Tweet 0 +1 0 Share Text Size – +

Tags: NASA, Space



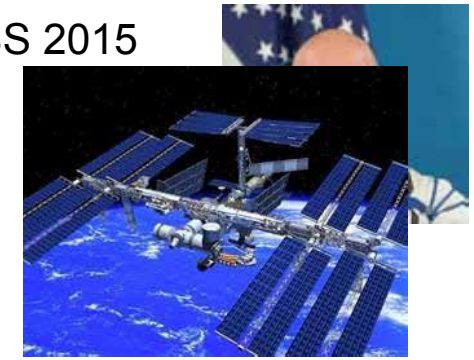
Twin Sons: Scott Kelly & Mark Kelly

Proposed Experimental Schema – "Twin Sons"

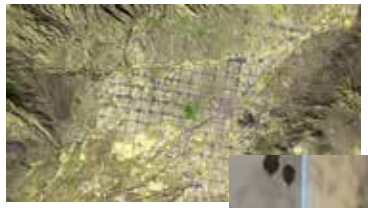
Observe existing genetic differences between the twins

Confirm presence of existing genetic differences between the twins immediately prior to launch

ISS 2015



Observe genetic differences between the twins following 1 year of spaceflight for Scott Kelly

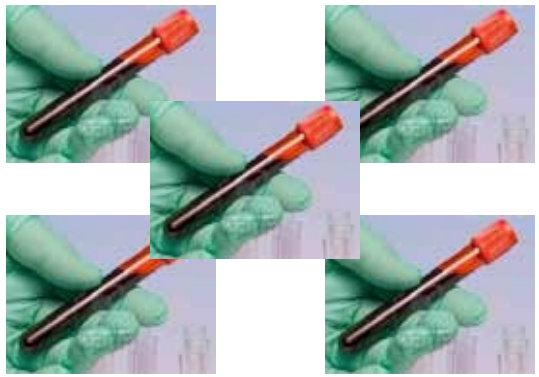


Tucson, AZ

Initial Baseline Phase
2013

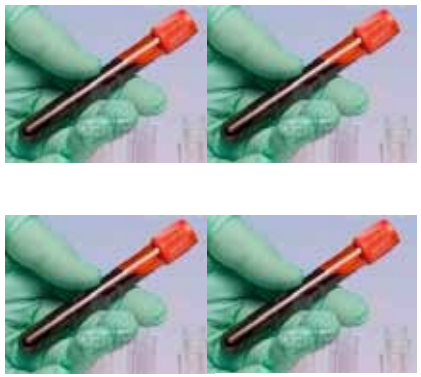
Pre-Launch Phase
2014

In Flight Phase
2015

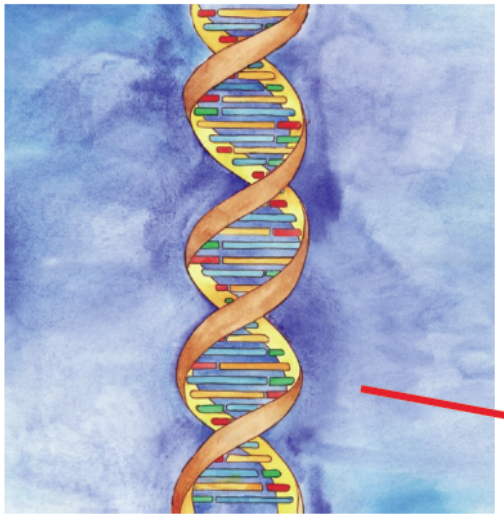


Sample @ 6 Hours, 3 weeks, 3, 6, 9 Months, and 51 Weeks into mission, (proposed)

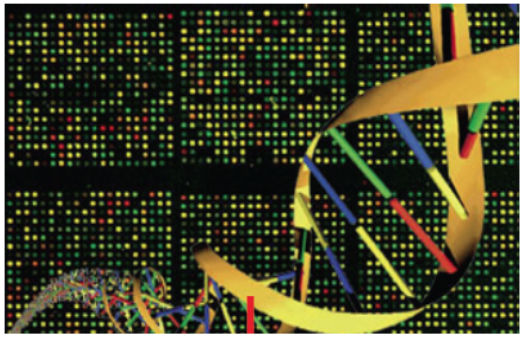
Post-Flight Phase
2016



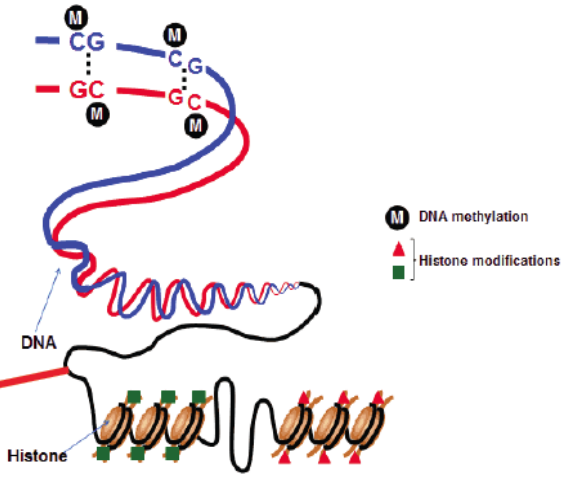
Perform Astro-Omics / Systems Biology



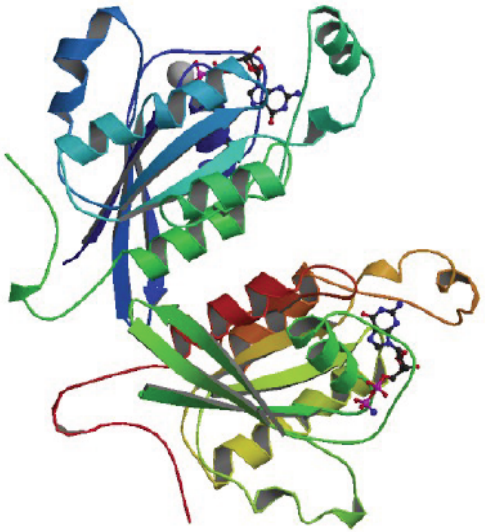
Genomics



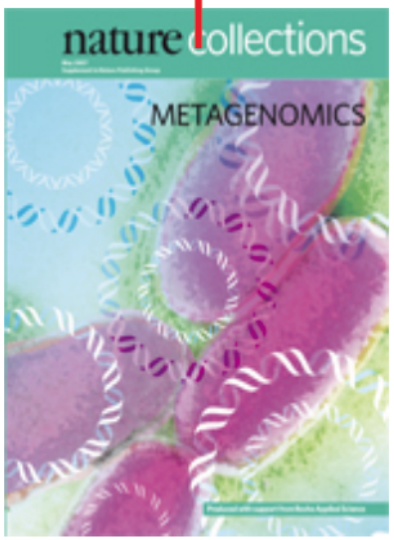
Transcriptomics, (RNA)



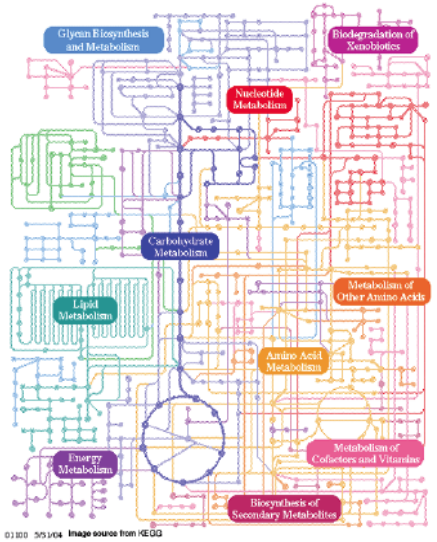
Epigenomics



Proteomics

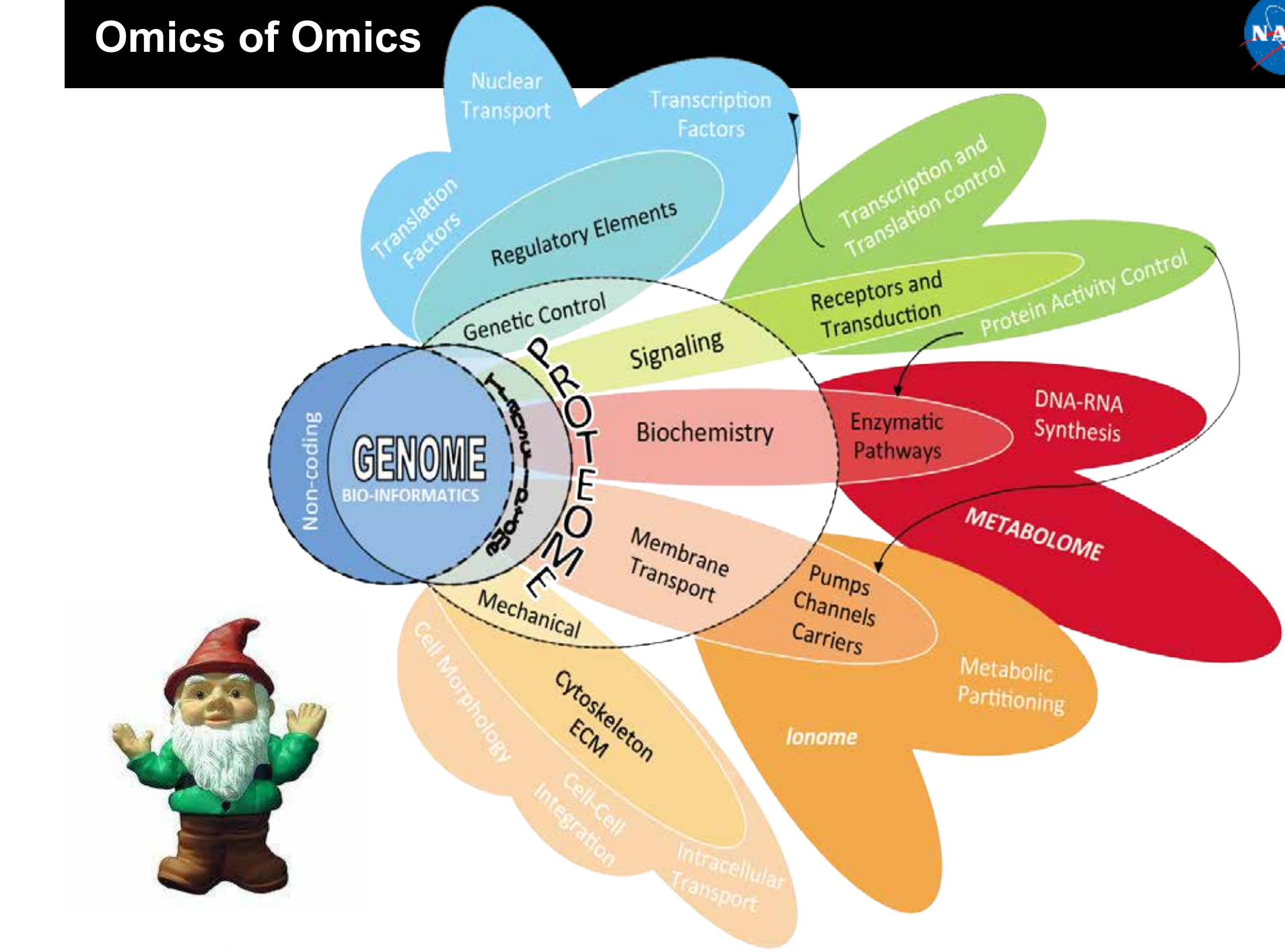


Metagenomics



Metabolomics

Omics of Omics



Selected Twin Study Investigations

- Immunome Changes in Space
- Longitudinal integrated multi-omics analysis of the biomolecular effects of space travel
- Proteomic Assessment of Fluid Shifts and Association with Visual Impairment and Intracranial Pressure in Twin Astronauts
- Differential effects on telomeres and telomerase in twin astronauts associated with spaceflight
- Metagenomic Sequencing of the Bacteriome in GI Tract of Twin Astronauts
- Comprehensive whole genome analysis of differential epigenetic effects of space travel on monozygotic twins
- The Landscape of DNA and RNA Methylation Before, During, and After Human Space Travel
- Cognition on Monozygotic Twin on Earth
- Metabolomic And Genomic Markers Of Atherosclerosis As Related To Oxidative Stress, Inflammation, And Vascular Function In Twin Astronauts
- Biochemical Profile: Homozygous Twin control for a 12 month Space Flight Exposure